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Speed Control of Switched Reluctance Motor Powered by Photovoltaic Energy

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Abstract: ***The work presented in this paper concerns the speed control of a switched reluctance motor (SRM) by use of a Maximum Power Point Tracking (MPPT) strategy applied to a SEPIC converter. A PV generator is used for energy supply. Fuzzy logic control has become an important methodology in many fields. This paper proposes a Fuzzy Logic Controller (FLC) to control the speed of SRM motor. The main objective of this work is to compare the operation of P& PI based conventional controller and gives the effective performance using Fuzzy Logic Control. The present work concentrates on the design of a fuzzy logic controller for the SRM speed control. Thus the result of applying fuzzy logic controller to a SRM drive gives the best performance and high robustness than a conventional P & PI controller. Simulation is carried out using Matlab simulink.***

Keywords: Switched Reluctance Motor (SRM); Photovoltaic's; MPPT control; SEPIC converter; fuzzy logic control;

I. INTRODUCTION

Photovoltaic Generators (PV) provide a clean and unlimited source of energy. As part of an ongoing project on low-cost PV-powered Electrical Vehicles, a control system is evaluated here for a specific configuration, based on PV panels that power a Switched Reluctance Motor, using independent controllers for maximizing the power supply and optimizing the operation of the motor. In this paper the simulink model for the speed control of switched reluctance motor is carried out by using different speed controllers. The simulink models is designed for P, PI & Fuzzy logic controller separately and their performance result is been compared. The Switched Reluctance Motor is an electric motor which runs by a reluctance torque. For industrial application very high speed of 50,000 rpm motor is used. The speed controllers applied here are based on conventional P& PI Controller and the other one is AI based Fuzzy Logic Controller.

The PI Controller proportional integral controller) is a most special case of the PID controller in which the derivative of the error is not being used. Fuzzy logic controller is a most intelligent controller which uses a fuzzy logic to process the input. Fuzzy logic is a many valued logic which is much like a human reasoning. In the industrial control FLC has various applications, particularly where this conventional control design techniques are very difficult to apply. A comprehensive reviews has done for SRM machine modelling, design and simulation and analysis and control.

To provide the maximum possible power in varying conditions, the control system aims to regulate the PV generators so that they are always at the Maximum PowerPoint (MPP) (which changes with the values of solar radiation and panel temperature and with the characteristics of the load connected to the PV). Therefore, a Maximum Power Point Tracking (MPPT) strategy is used in order to obtain the maximum available power from the panel. Many methods have been developed to determine Maximum Power Point Tracking (MPPT): This paper considers the problem of coupling these energy sources to power an electrical motor in an off-grid application. When a SRM load is supplied from the PV generator via a SEPIC converter then the duty cycle is controlled using a specific MPPT controller. In this study, the converter duty cycle is calculated and adjusted in order to maximize power operation of the whole installation.

II. SYSTEM DESCRIPTION

A Switched Reluctance Motor is a singly excited, doubly- salient machine in which the electromagnetic torque is been developed due to variable reluctance principle. Both stator and rotor has salient poles but only the stator carries windings. As in dc motor the SRM has a wound field coils for stator windings. However the rotor has been no attached coils or magnets. The projecting magnetic poles of salient pole rotor are made of very soft magnetic material. When the excitation is given to a stator windings, a force is created by rotor's magnetic reluctance to align the rotor pole with its adjacent stator pole. In order to preserve sequence rotation, the windings of its stator pole switches in its sequential manner with the help of electronic control system so that the magnetic field of the rotor pole was lead by the stator pole, pulling towards it. The rotor pole is said to be the "fully unaligned position" when the rotor pole is an equidistant from its two adjacent stator pole. This position is called as maximum magnetic reluctance for its rotor pole. In the aligned position the rotor poles are fully aligned with its stator poles, this position is called as the minimum reluctance of rotor pole. The equation determines that the developed torque depends only on the current magnitude and $dL/d\Theta$ direction but it is independent on the current direction.

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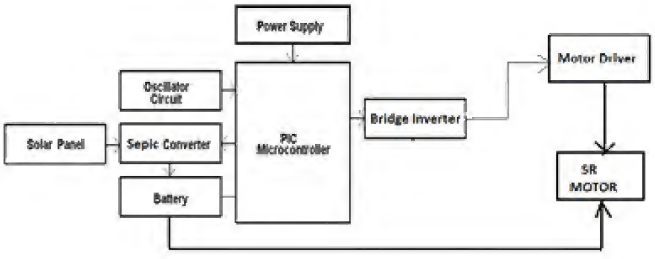

Fig.01. Block Diagram of Proposed System

a. Block Diagram

From the Fig.01 the position of rotor is being sensed by the rotor position sensor and it provides its corresponding output to its error detector. Error detector compares the reference speed and actual speed to provide error signal which is given to controller block. Thus the controller either fuzzy or the PI gives the control signal to the converter according to its error signal. The speed of the motor is been controlled by the converter through proper excitation of their corresponding windings.

i. Photovoltaic Generator

The PV generator consists on many photovoltaic modules adequately connected in series and parallel and to provide its desired voltage and current required by the system. The specific characteristics of the PV generator depend generally on the number of modules connected in series (ns) and parallel (np), that are selected according to type of the solar modules used, and the expected solar radiation, and ambient temperature of the location

where the PV generator would be used. The equivalent circuit for each solar module, internally arranged in np parallel and Ns series cells.

ii. MPPT Control Strategy

MPPT is essentially a real time process to locate the combination of current and voltages at the output of the PV generator that give the maximum possible power that can be extracted from the PV under given operating conditions .Although there are many MPP tracking methods, the most frequent is the P&O algorithm. The principle of this control algorithm is to generate small disturbances on by reducing or increasing the duty cyclic and observing the effect on the power output of PV generator.

III. SPEED CONTROL OF SRM USING FUZZY LOGIC CONTROLLER

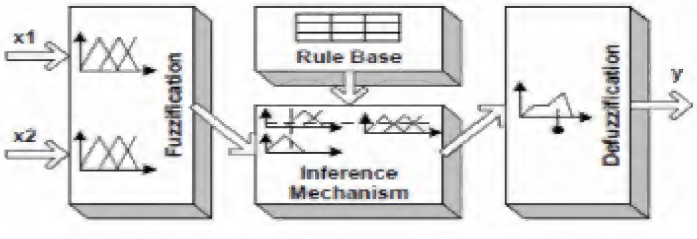

Fig 2. Structure of Fuzzy Logic Controller.

The merits of fuzzy logic controller are the clarification for a problem can be very easily analysed and the design of the controller can be easily implemented. The design of fuzzy logic system is not based on its mathematical model of process. The four main stages in fuzzy logic controller (Figure 2): fuzzification, rule base, inference mechanism and the defuzzification as shown in the Figure 3. The surface view of FLC is shown in Figure 4. Thus the fuzzification is nothing but it comprises the process of transpose crisp values into the grades of membership for linguistic terms of fuzzy sets. The transpose from the fuzzy set to a crisp number is called the defuzzification. The inference engine and its knowledge base were the components of an expert system. This knowledge base stores the factual knowledge of the operation of the concern experts. Fuzzy inference engine is the best process for calculating a given input to an output using fuzzy logic. In inference engine, If Then type fuzzy rules converts the fuzzy input to its output.

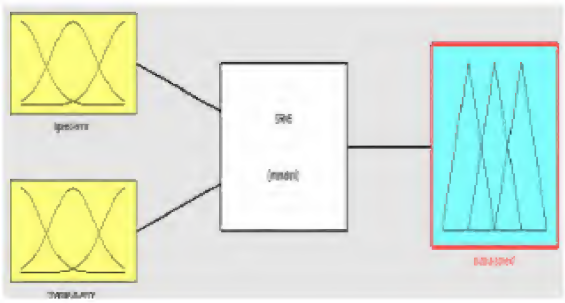

Fig 3. Fuzzy Inference System of SRM

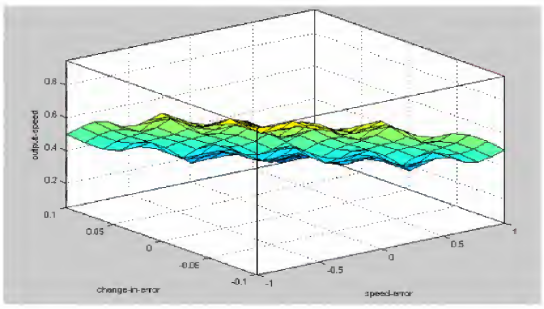

Fig 4. Surface view of FLC

Δe \ e	NL	NM	NS	ZR	PS	PM	PL
NL	PL	PL	PM	PM	PS	PS	ZR
NM	PL	PM	PM	PS	PS	ZR	NS
NS	PM	PM	PS	PS	ZR	NS	NS
ZR	PM	PS	PS	ZR	NS	NS	NM
PS	PS	PS	ZR	NS	NS	NM	NM
PM	PS	ZR	NS	NS	NM	NM	NL
PL	ZR	NS	NS	NM	NM	NL	NL

Table 01. FLC Rule Table

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Mamdani type fuzzy logic controller is the most commonly used in a closed loop control system, because it reduces the steady state error finally to zero. The designed fuzzy rules based used in this research are given in Table 1. The fuzzy logic sets have been defined as: the negative large (NL), the negative medium (NM), the negative small (NS), zero (ZR), and positive small (PS), positive medium (PM) and the positive large (PL) respectively. Many research papers have developed SRM models based on the fuzzy logic, hybrid fuzzy and neural techniques2–4. The simulink model is designed for the speed control of Switched Reluctance Motor by using Fuzzy logic controller and their corresponding waveform is shown in Figures 5-09.

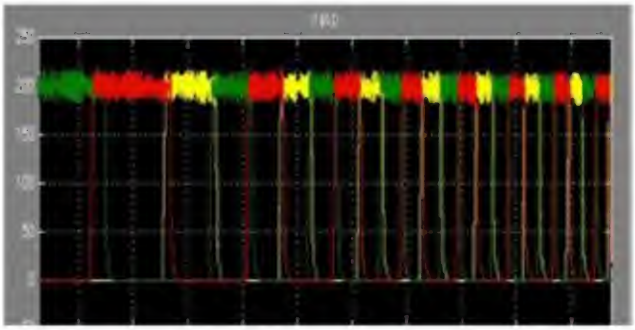

Fig.05 Simulink Model of FLC System

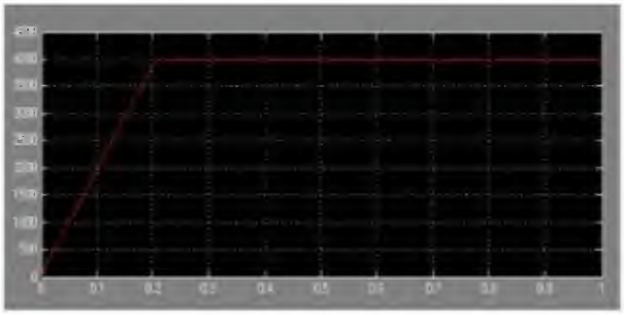

Fig 06. Current Waveform

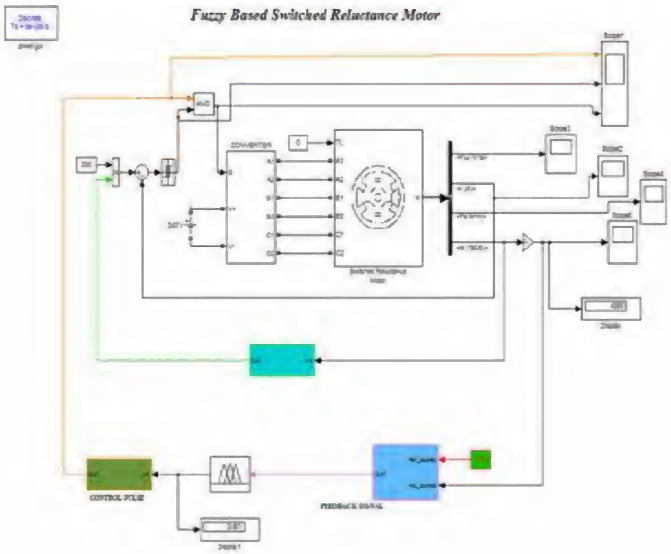

Fig 07. Speed Waveform

If set speed is 4000, the actual speed displayed as 4000 and the settling time is given as 0.2. From the speed waveform, it can be notified that the fuzzy logic controller enhances its speed regulation and it is a best speed tracking without overshoot. The Table 2 shows speed comparison of the proportional controller, proportional integral controller and fuzzy logic controller. For the reference speed is 4000, the following actual speed and its settling time were been obtained.

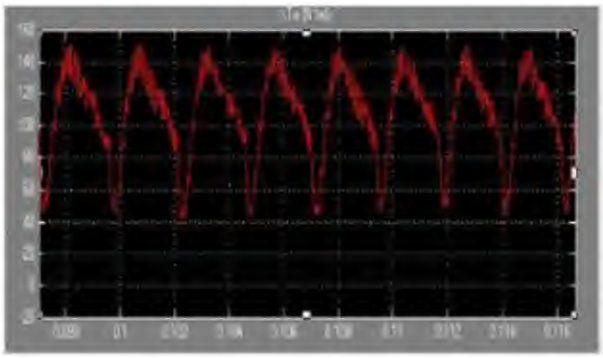

Fig 08. Output Torque of Drive

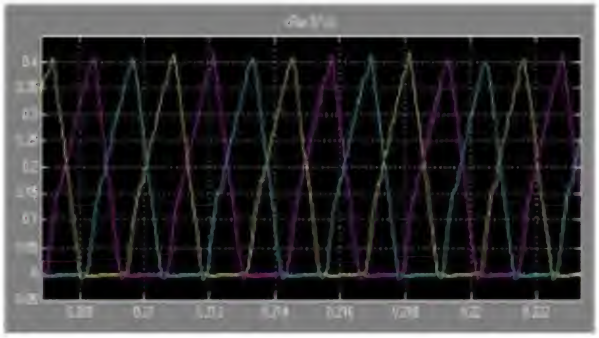

Fig 09. Output Flux of Drive

IV.CONCLUSION

In this work the SRM dynamic performance is implemented by using MATLAB/simulink. In conventional methods the speed control of SRM motor is concluded by P, PI. Here it is executed with Fuzzy Logic Controller. Fuzzy Logic Controller gives the required output than the other controllers. In this proposed method the fuzzy logic controller ensure excellent reference tracking of switched reluctance motor drives. This fuzzy logic controller gives the best speed tracking without overshoot and enchances the speed regulation.

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